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## ANTHELMINTICS FOR THE REMOVAL OF THORN-HEADED WORMS FROM SWINE

By WILLARD H. WRIGHT and H. B. RAFFENSPERGER, *Associate Veterinarians,  
Zoological Division, Bureau of Animal Industry*<sup>1</sup>

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### INTRODUCTORY NOTE

A search of the literature reveals few references to critical tests of anthelmintics for the removal of thorn-headed worms from swine. In spite of the considerable economic importance of this parasite, both in the United States and elsewhere, little attention has apparently been paid to treatment. Hall (3)<sup>2</sup>, in 1924, stated that the distribution of the parasite is world-wide, it being found in North America, South America, Europe, Asia, Africa, Australia, and Madagascar.

The thorn-headed worm attaches to and embeds its head in the wall of the small intestine by means of five rows of well-defined, projecting hooks and causes a local, inflammatory reaction and some necrosis. Apparently because of its tenacious hold on the intestinal wall, it has proved to be resistant to the action of the various anthelmintics which have been tested for its removal.

### THE LIFE CYCLE OF THE THORN-HEADED WORM

An effective anthelmintic treatment for the thorn-headed worm is the more desirable because the life history of the parasite is such that control by any other method is difficult, if not entirely impracticable. The eggs which pass in the feces of the host may be swal-

<sup>1</sup> The first three sections were written by Willard H. Wright and the fourth, Tests of Anthelmintics, by H. B. Raffensperger.

<sup>2</sup> Reference is made by italic numbers in parentheses to Literature Cited, p. 11.

lowed by May-beetle larvae or other beetle larvae as they feed in manure from infested swine or on soil contaminated with such manure. In the beetle, the young worm escapes to the body cavity, where it encysts. The encysted worms remain in the body cavity after the metamorphosis of the beetle larvae to adults. When swine eat either the larvae or the adult beetles, the insects are digested, and the worms are released to develop to maturity in the intestine of the pig. In order to prevent infestation, swine would have to be prevented from rooting over areas infested with the grubs and be so confined that they would not have an opportunity to ingest adult beetles. Not only would this be difficult, but in addition the eating of grubs by swine is an aid in controlling the grubs. While it is possible to apply methods for keeping down grub infestation in the soil, the complete prevention of thorn-headed-worm infestation would obviously be a difficult and expensive procedure. In view of this fact, it is highly desirable to have an anthelmintic which is effective against these worms.

### REVIEW OF THE LITERATURE REPORTING EXPERIMENTAL RESULTS

Calandruccio (1), in 1890, reported the removal, from himself, of 53 thorn-headed worms, *Moniliformis moniliformis*, with no evidence of worms present subsequently, following the administration of a dose of 8 grams of ethereal extract of male fern, and Hall (2) suggested, in 1922, that male fern may be of value for removing thorn-headed worms from swine. Raffensperger's experiments, reported in the following section of this publication, and those of Wolffhügel (9) quoted below, indicate that the drug is apparently without action on *Macracanthorhynchus hirudinaceus*.

Connaway, Backus, and Tucker, as reported by Mumford (8) stated, in 1915, that in their experiments "copper sulphate was found to be the most efficient in expelling the thorn-headed worm." However, the protocols are not given for these experiments, and the percentage of efficacy is not stated. In the absence of such critical information, judgment on the value of copper sulphate for the removal of the parasite in question must be withheld.

Wolffhügel (9), in 1924, tested a large number of preparations for the removal of thorn-headed worms, all the drugs showing little or no value for that purpose. Wolffhügel's results are given in the following summary:

Oil of turpentine, 12 grams in sweet oil, to one 8-months-old pig, followed in 3¾ hours by 5 grams of powdered aloes and 10 grams of magnesium sulphate, removed 1 thornhead and left numerous others.

Santonin was given to an 8 to 9 months old pig in a dose of 1 gram with 100 grams of castor oil in dry clay. Two days later the animal received 5 grams of santonin, and seven days later 9 grams of santonin with 50 per cent alcohol administered with a syringe, followed in 3 and one-half hours by 10 drops of croton oil in olive oil. The pig died the next morning. No worms were passed following the treatment, but 18 thornheads were found on post-mortem examination. Santonin, therefore, was entirely ineffective against thornheads.

Extract of male fern was given to one pig in a dose of 6.7 grams with 20 grams of sulphuric ether. Nine days later the pig was given 10 capsules, each containing 0.33 gram of male fern, followed by milk. The next morning 5 grams of male-fern extract were given, followed in three hours by 20 drops of croton oil in 250 grams of olive oil. The treatment was entirely ineffective.

Picric acid was given to one 9 to 10 months old pig in a dose of 0.5 gram. Four days later the pig was given 1 gram in water, and the next day, 3 grams in 40 per cent alcohol. The treatment was entirely ineffective.

One 8 to 9 months old pig was given 15 grams of carbon disulphide in 100 grams of olive oil. The next day the pig received 25 c. c. of carbon disulphide with 150 grams of olive oil. Four days later the pig was given 50 c. c. of carbon disulphide with 200 c. c. of oil. After seven days it was given 100 c. c. of carbon disulphide with 100 grams of castor oil. The treatment failed to remove any thornheads.

Sodium arsenite in a dose of 0.1 gram in water given to one 8 to 9 months old pig, followed the next day by 0.2 gram in water, and the following day by 0.5 gram in water, of which 0.1 gram was lost in dosing, failed to remove any thornheads.

Naphthalene in a dose of 5 grams in oil given to one 8 to 9 months old pig, followed in 6 days by 10 grams in oil, was entirely ineffective against thornheads.

Calomel, in a dose of 7 grams, was entirely ineffective in the removal of thornheads from one pig after it had fasted 12 hours.

One 8 to 9 months old pig was given 100 c. c. of glycerin and 1 gram of ferric chloride with 400 grams of water. The next day the pig received 200 grams of glycerin, 2 grams of ferric chloride, and 300 grams of water. The treatment failed to remove any thornheads.

One 8 to 9 months old pig was given 100 grams of glycerin, 10 grams of chloroform, and 200 grams of a 1 per cent solution of potassium ferrocyanide without any effect on the thorn-headed worms.

Lysol in a dose of 10 c. c. with 2 liters of flour paste failed to remove any thornheads from one pig.

Benzine in a dose of 50 grams, followed in six days by 100 c. c. in 300 grams of olive oil, failed to remove any thornheads from one 8 to 9 months old pig.

Potassium cyanide was given to one pig in a dose of 0.15 gram in 200 grams of water and 20 grams of milk. Four days later the pig received 0.3 gram of potassium cyanide in 200 grams of water. The treatment was entirely ineffective for thornheads.

Balsam of Peru in a dose of 3 grams with 200 grams of olive oil given to one pig fasted 24 hours was entirely ineffective in the removal of thornheads.

Powdered sulphur in a dose of 2 grams failed to remove any thornheads from one pig.

One 10-months old pig was given 1.7 grams of tobacco extract containing 8.5 per cent of nicotine in clay. Three days later the pig was given 5 grams of the extract in 2 liters of clay. The treatment was without effect on the thornheads.

Tartar emetic given to one pig in a dose of 1 gram dissolved in water and mixed with clay, followed in three days by 2 grams with water, milk, and soup, failed to remove any thornheads.

Borax in a dose of 2 grams in clay was without effect on thornheads.

Thymol in a dose of 4 grams with 1 c. c. of alcohol, 300 grams of water, 30 grams of glycerin, and 4 grams of sugar, failed to remove any thornheads from one pig.

Copper oxide given to one 8 to 9 months-old pig in a dose of 0.4 gram of clay, this dose being repeated four days later, was entirely ineffective for thornheads.

Salicylic acid given to one pig in a dose of 5 grams in clay was ineffective against thornheads.

Bismuth subnitrate in a dose of 4 grams in clay was ineffective against thornheads, as was vinegar in a dose of 100 c. c., and iodoform in a dose of 0.4 gram given with egg.

One 8 to 9 months-old pig was given 2 grams of powdered pyrethrum flowers in the feed at 10 o'clock in the morning, and at 6 o'clock in the evening was given 28 grams of the same product in meat broth. The treatment was entirely ineffective.

One pig was given 200 c. c. of a remedy containing 100 grams of petroleum; this was entirely ineffective in removing thornheads.

In Wolffhügel's tests, turpentine was the only drug showing any efficacy against thorn-headed worms; it removed one worm and left a considerable number of others. The dosages of the drugs used in the foregoing tests are generally rather high and in many cases greatly in excess of the usual therapeutic dose. However, many of these preparations are not considered as coming under the classifi-

cation of anthelmintics, although some, such as turpentine, santonin, male fern, carbon disulphide, sodium arsenite, and thymol have considerable anthelmintic efficacy against certain parasites of different species of animals, including man. Some criticism might be directed at the method of administering drugs in the clay preparation. In general, anthelmintics administered in the feed or with other bulky substances do not maintain the same efficacy as when given alone. However, the use of clay as a vehicle for administering drugs has not been tested with the standard anthelmintics, and it is not possible to say just what influence the clay would have on the efficacy of the drug.

Kovářzik (6), in 1923, reports on the treatment of a herd of 50 swine with a product marketed under the name of Vermithan. Two animals in this herd had died before treatment was undertaken, apparently as a result of a heavy infestation with thornheads. Following the treatment, the herd improved in condition. One animal died two days after treatment and was found to have an intestinal obstruction due to the clumping of numerous thornheads, which were found dead.

Magyary-Kossa (7), in 1922, gave the composition of Vermithan as a 10 per cent solution of isobornylacetate, pine camphor, and juniper extract in carbon tetrachloride. According to Magyary-Kossa, the dose of this preparation for swine is 0.5 gram per kilogram of body weight, the drug to be followed by from 1 to 1.5 grams of calomel. Unfortunately Kovářzik gives no information as to the dose he used. Furthermore, his evidence on the value of Vermithan is of a clinical nature and is not substantiated by critical tests.

Kocourek (5), in 1877, reported remarkable improvement in a herd of swine following treatment for thornheads with turpentine in doses of 2 grams with double that amount of a flaxseed decoction. This was later followed by 10 grams of Epsom salt and 5 grams of aloes. Kocourek's results are not based on critical data and are not substantiated by Wolffhügel's critical test, which indicated that turpentine is of no appreciable value for the removal of thornheads.

#### SUMMARY

In summarizing the literature on the treatment of thorn-headed worms in swine, it is found that turpentine, first recommended on clinical grounds, showed little efficacy when tested critically.

Extract of male fern, which in a dose of 8 grams apparently removed all *Moniliformis moniliformis* from one infested person, failed in doses of 4 c. c. in Raffensperger's experiments and in doses of 6.7, 3.3, and 5 grams, respectively, in Wolffhügel's experiments, to remove any thornheads from swine.

In critical tests conducted by Wolffhügel, santonin, picric acid, carbon disulphide, sodium arsenite, naphthalene, calomel, glycerin-ferric chloride, glycerin-chloroform-potassium cyanide, lysol, benzine, thymol, potassium cyanide, balsam of Peru, sulphur, tobacco extract, copper oxide, salicylic acid, tartar emetic, borax, bismuth subnitrate, vinegar, iodoform, pulverized pyrethrum flowers, and petroleum were without any value whatsoever against thornheads.

## TESTS OF ANTHELMINTICS

This report covers experiments conducted by one of the authors (H. B. R.), in Chicago, during the period from 1922 to 1928, inclusive, on the treatment of swine for the removal of the thorn-headed worm, *Macracanthorhynchus hirudinaceus*.

## EXPERIMENTAL PROCEDURE

## EXPERIMENT 1

## CARBON TETRACHLORIDE (25 c. c.)

Fifteen pigs, weighing about 125 pounds each, shipped from Alabama, were used. Fecal examination of 12 of the 15 showed *M. hirudinaceus* ova.

Feed was withheld for 36 hours, and on March 1, 1922, each of the 15 pigs was given 25 c. c. of carbon tetrachloride ( $\text{CCl}_4$ ) in 75 c. c. of castor oil. All feces were collected, washed, and examined for the entire group, not for each pig separately. Fecal examination from March 2 to March 6 showed for each successive day the following: 4 thornheads; 5 thornheads, 2 large ascarids, 1 small ascarid (*Ascaris suum*), and 1 nodular worm (*Oesophagostomum dentatum*); 1 thornhead; 2 thornheads. Total worms passed, 12 thornheads, 3 ascarids, 1 nodular worm.

The pigs were slaughtered March 6, and 89 *M. hirudinaceus* were found, attached and alive. The swine hookworm, *Globocephalus longemucronatus* (synonym *Crassisoma urosulatum*), was found in the small intestines in large numbers. Since only 12 thornheads were passed and 89 were found upon post-mortem examination, the carbon tetrachloride was only 11.8 per cent effective against thornheads in this experiment.

## EXPERIMENT 2

## CARBON TETRACHLORIDE (32 c. c.)

Twelve pigs, shipped from the Southwest, weighing from 100 to 125 pounds each, were used in this experiment. Instead of a fecal examination of these pigs, a post-mortem examination of 25 pigs from a similar lot was made on the killing floor and the intestines were found to be infested with *M. hirudinaceus*; in one pig 58 thornheads were counted.

On March 22, 1922, each of the 12 pigs was given 32 c. c. of carbon tetrachloride in 96 c. c. of castor oil, a metal dosing syringe being used. Feed had been withheld for 36 hours, but by a mistake some corn was thrown into the pen one-half hour before dosing. Fecal examination of the manure from the entire group from March 23 to March 30 showed for each successive day the following: No worms; 3 thornheads; 2 thornheads; no worms the last five days. Total worms passed, 5 thornheads. Three pigs died after treatment, one on March 23, probably from injury, another on March 27, 1922, and another on March 28, 1922. These pigs were not examined, and the cause of death was not determined.

The nine remaining pigs were slaughtered on March 30 and 47 thornheads were found. Disregarding the three pigs which died after treatment, the carbon tetrachloride was 9.6 per cent effective against thornheads.

#### EXPERIMENT 3

CARBON TETRACHLORIDE (30 C. C.) AND 15 C. C. OF 1 PER CENT NICOTINE-SULPHATE SOLUTION

Five rough-looking pigs were selected at random at one of the Chicago packing houses. The average live weight was 143 pounds. Fecal examination showed all pigs to be positive for ascarids but only one was positive for thornheads.

On April 14, 1928, each pig was given 30 c. c. of carbon tetrachloride and 15 c. c. of a 1 per cent nicotine-sulphate solution by stomach tube. Examination of the composite feces April 15 to April 19, inclusive, showed the following for each successive day: 4 ascarids; no worms; 1 ascarid and 1 thornhead; no worms. The pigs were killed April 20, six days after treatment. The intestines were carefully examined for parasites, and no thornheads or ascarids were found. The treatment was 100 per cent effective for thornheads and ascarids.

All five pigs were condemned for icterus. The livers were very pale, showing fatty degeneration, the bile was thick in the gall bladder, and there was a very marked yellow appearance of the fat throughout the carcasses. Cut and stained sections showed fatty degeneration of liver cells with a central necrosis of the lobules of the liver.

#### EXPERIMENT 4

ETHEREAL EXTRACT OF MALE FERN

Twelve pigs from the South, with an average weight of 65 pounds, were used.

These pigs were held without feed for 36 hours, and on April 23, 1923, each of the 12 was given 4 c. c. of ethereal extract of male fern in hard gelatine capsules, followed by 30 c. c. of castor oil. Fecal examinations from April 23 to April 30, inclusive, showed no worms passed. In the meantime two pigs died of cholera.

On April 30 the 10 remaining pigs were killed, and 19 thornheads and 38 ascarids were found upon post-mortem examination. Male fern in this test was of no value for the removal of thornheads or ascarids.

#### EXPERIMENT 5

TETRACHLOROETHYLENE AND MAGNESIUM SULPHATE

Nineteen pigs from the Southwest were used in this experiment. One of the nineteen pigs was killed, and 63 thornheads and several ascarids were found in the small intestine.

On November 15, 1927, one lot of six pigs was dosed with tetrachlorethylene ( $C_2Cl_4$ ) and magnesium sulphate as follows: Two pigs were each given 2 No. 11 capsules each filled with dry magnesium sulphate to which was added 5 c. c. of tetrachlorethylene. Four pigs were each given 4 such capsules. A balling gun was used for dosing. Composite feces were examined after dosing.



Fecal examination, November 16 to November 23, inclusive, showed the following for each successive day: No worms; 3 ascarids; 1 thornhead; no worms the last four days. Total worms passed, 1 thornhead, 3 ascarids.

The pigs were killed November 25 and showed the following worms, upon post-mortem examination: 33 thornheads; 3 ascarids; 23 thornheads; 4 nodules but no thornheads; 6 ascarids; 43 small ascarids; 50 thornheads and 12 ascarids; 12 nodules with 1 immature thornhead. Total worms post-mortem, 107 thornheads, 64 ascarids. Efficiency against thornheads, less than 1 per cent; against ascarids, about 4.5 per cent.

#### POWDERED KAMALA AND KAMALA EXTRACT

The other pigs were disposed of as follows: Two pigs were discarded, as fecal examinations were negative for thornheads. One pig died of hog cholera December 6, and the remaining pigs were immunized against that disease. One pig was given 14 grams of powdered kamala on November 17. Feces collected and examined for six consecutive days showed no parasites passed. This pig was killed December 5 and eight thornheads and several ascarids were found. Kamala in this test was entirely ineffective against thornheads and ascarids.

On December 8 two pigs were each given 30 c. c. of kamala extract made as follows: To 45 grams of kamala 96 c. c. of carbon tetrachloride was added and the solution allowed to stand for 48 hours; it was then filtered. The filtrate of carbon tetrachloride and the portion of kamala soluble in this solvent were given through a stomach tube. Fecal examinations December 9 to December 15, inclusive, showed the following: No worms; 1 ascarid; no worms; no worms; 1 thornhead. Total worms passed, 1 thornhead, 1 ascarid.

The pigs were killed December 16. One pig had no parasites, but showed eight nodules where thornheads had been attached. One pig had 5 thornheads attached and 3 nodules; this latter pig had passed the 1 thornhead and 1 ascarid. The drug was therefore 17 per cent efficient against thornheads and 100 per cent efficient against ascarids.

#### MAGNESIUM SULPHATE AND NICOTINE-SULPHATE SOLUTION

On December 19 each of two other pigs, designated as No. 41 and No. 43, was given 15 grams of magnesium sulphate in 250 c. c. of water by stomach tube. Feed was withheld until after dosing the next day, when each pig was given 120 c. c. of nicotine-sulphate solution made by adding 15 c. c. of a 40 per cent nicotine-sulphate solution to 960 c. c. of water. This made about a 1.5 per cent solution, which was given with a stomach tube. The pigs showed no symptoms of sickness after being dosed. Fecal examinations, December 21 to December 23, inclusive, showed for each successive day the following: Pig No. 41; 1 ascarid; no worms; 1 thornhead; total, 1 thornhead, 1 ascarid. Pig No. 43; no worms; 3 thornheads; no worms; total, 3 thornheads.

The pigs were killed December 23. Post-mortem examination showed the following: Pig No. 41, 2 thornheads and 3 ascarids; pig

No. 43, 64 thornheads. Pig No. 41 passed 1 thornhead and had 2 on post-mortem examination; the nicotine sulphate in this case was 33.3 per cent effective. Pig No. 43 passed 3 thornheads and had 64 on post-mortem examination; the drug was only about 4.5 per cent effective against thornheads. Pig No. 41 passed 1 ascarid and had 3 upon post-mortem examination; the drug was 25 per cent effective against ascarids.

#### IODINE SOLUTION

Four pigs from the same lot were used in an experiment on December 28. One pig was given 120 c. c. of a hyperactive iodine solution. This pig passed no worms in the next five days and was killed the sixth day after treatment. Upon post-mortem examination it had 13 thornheads. The drug was entirely ineffective against thornheads.

#### CARBON TETRACHLORIDE (45 C. C.)

Another pig was given 45 c. c. of carbon tetrachloride with 45 c. c. of castor oil. Fecal examinations for the next five days showed: No worms; 6 ascarids; 9 ascarids; no worms; 2 thornheads; 1 ascarid. Total, 2 thornheads; 16 ascarids. The results of a post-mortem examination on the sixth day after treatment were as follows: No worms; 8 nodules due to thornheads. The treatment was 100 per cent effective against thornheads and ascarids.

#### LIQUOR CRESOLIS COMP. U. S. P.

Another pig was given 4 c. c. of liquor cresolis comp. U. S. P. in 196 c. c. of water, and died the following night, apparently as a result of the treatment.

#### KAMALA EXTRACT

The fourth pig of the lot was given 60 c. c. of a kamala extract made with 56 grams of kamala in 130 c. c. of carbon tetrachloride. The kamala was left in the carbon tetrachloride for 48 hours and then filtered. The dose was administered with a stomach tube. No worms were passed in the next three days, and the pig was found dead on the fourth day. There was no post-mortem examination, but the feces of this pig had shown eggs of thornheads on examination, December 16, and the drug was evidently entirely ineffective in removing thornheads.

#### EXPERIMENT 6

#### OIL OF CHENOPodium

Seventeen pigs from the Southwest, with an average weight of 80.6 pounds, were used. On January 15, 1923, each pig was given 1 c. c. of oil of chenopodium in a hard gelatine capsule and 64 c. c. of castor oil by means of a metal dosing syringe. Fecal examinations of the manure from the entire group from January 16 to January 19, inclusive, showed no worms passed. The pigs were slaughtered January 19, and large numbers of thornheads were found. Two feet of intestines of one pig were examined and 80 thornheads were found in this specimen. Oil of chenopodium in this test was of no value against thornheads.

## DISCUSSION

## CARBON TETRACHLORIDE

Carbon tetrachloride in these tests showed some efficacy against thorn-headed worms. In doses of 25 c. c. in 75 c. c. of castor oil it removed 11.8 per cent of the thornheads present in 15 pigs of an average weight of 125 pounds. In doses of 32 c. c. in 96 c. c. of castor oil, carbon tetrachloride removed 9.6 per cent of the thornheads present in 12 pigs weighing from 100 to 125 pounds each. The drug administered in a dose of 45 c. c. in 45 c. c. of castor oil removed all the thornheads from one pig. Carbon tetrachloride in doses of 30 c. c. combined with 15 c. c. of a 1 per cent solution of nicotine sulphate, administered to 5 pigs of an average weight of 143 pounds, was 100 per cent effective against thornheads. It is apparent from these tests that the drug must be given in relatively high doses in order to be effective. Hall and Shillinger (4), in 1923, stated that the therapeutic dose rate of carbon tetrachloride for swine is 0.6 c. c. per kilogram of body weight, while the minimum lethal dose rate is between 1.66 and 3 c. c. per kilo. The factor of safety, therefore, is between 2.66 and 5 (i. e., the minimum lethal dose is 2.66 to 5 times the therapeutic dose), a very small margin as compared with a relatively high factor of safety for poultry and some other animals. They conclude that "swine are, therefore, rather poor subjects for treatment with carbon tetrachloride or other drugs acting on the liver \* \* \* a fact probably associated, among other things, with the prevalence of parasitic hepatic cirrhosis in swine." This observation is borne out in these experiments when the drug was combined with a 1 per cent nicotine-sulphate solution, the treatment resulting in the condemnation of all the pigs for icterus and the presence of fatty degeneration and central necrosis in the livers of these animals. The weight of the pig receiving 45 c. c. of the drug was not determined, but the average weight of the pigs receiving 30 c. c. of the drug combined with a 1 per cent nicotine-sulphate solution was 143 pounds or 65 kilos. The dose rate of the carbon tetrachloride in this instance, therefore, was 0.46 c. c. per kilogram or 27.7 per cent of the minimum lethal dose of 1.66 c. c. per kilogram, taking the lowest figure of Hall and Shillinger. This does not leave a wide margin of safety for the drug, and it would not seem that carbon tetrachloride could be generally recommended for use at such a dose rate. It would appear, therefore, that while carbon tetrachloride possesses a fair degree of efficacy against thorn-headed worms, the margin of safety is so small that its general use might be hazardous. The combination with nicotine looks promising and deserves further test.

## EXTRACT OF MALE FERN

Ethereal extract of male fern given to 12 pigs of an average weight of 65 pounds each, in doses of 4 c. c. followed by 30 c. c. of castor oil, failed to remove any of the thornheads or ascarids present. Male fern is primarily a taeniocide and it is not to be expected that it would show any great efficacy against roundworms. As the zoological affinities of the acanthocephalids are not well established, there was the possibility that they might respond to treatments for tapeworms as well as to those for nematodes, or perhaps better.

## TETRACHLORETHYLENE AND MAGNESIUM SULPHATE

Tetrachlorethylene in doses of 10 c. c. with magnesium sulphate, and in doses of 20 c. c. with magnesium sulphate, was less than 1 per cent effective against thornheads and only about 4.5 per cent effective against ascarids. These doses are less than those of carbon tetrachloride in these tests, and it is possible that tetrachlorethylene in higher doses might show some efficacy where smaller doses have failed. The evidence to date indicates that tetrachlorethylene is probably a safer drug for use in some animals than is carbon tetrachloride. It is possible, therefore, that larger doses may be given with safety to swine. Additional tests with this drug are needed to determine the largest safe dose.

## KAMALA

Kamala in a dose of 14 grams to one pig failed to remove any thornheads or ascarids. Kamala, like male fern, is a taeniicide. A kamala extract made by adding 45 grams of the drug to 96 c. c. of carbon tetrachloride and allowing it to stand 48 hours, was 17 per cent effective against thornheads and 100 per cent effective against ascarids. In another test a kamala extract made by adding 56 grams of the drug to 130 c. c. of carbon tetrachloride and allowing it to stand 48 hours, failed to remove any thornheads from one pig. The kamala in this combination apparently reduced the efficacy of carbon tetrachloride.

## NICOTINE SULPHATE

A 1.5 per cent solution of 40 per cent nicotine sulphate in doses of 120 c. c., preceded by a purgative, given to each of two pigs, was, respectively, 33.3 per cent and 4.5 per cent effective for thornheads, and in one pig, was 25 per cent effective against ascarids. The combination of nicotine sulphate and carbon tetrachloride, which was 100 per cent effective against thornheads, appears to derive some efficacy from both carbon tetrachloride and nicotine sulphate. This mixture deserves further test. A solution of 40 per cent nicotine sulphate combined with a 1 per cent solution of copper sulphate is an effective remedy for stomach worms (*Haemonchus contortus*), hookworms, and tapeworms of sheep, and nicotine sulphate combined with a selected fuller's earth is used for the removal of Ascaridia from poultry.

## IODINE SOLUTION

A hyperactive iodine solution given to one pig in a dose of 120 c. c. failed to remove any thornheads. While it is not advisable to conclude very much from a single test, the iodine preparation did not appear to be so promising as some other drugs used in these experiments. Additional tests should be made.

## LIQUOR CRESOLIS COMP. U. S. P.

A dose of 4 c. c. of liquor cresolis comp. U. S. P., in 196 c. c. of water given to one pig, resulted in the death of the animal. This preparation is therefore too toxic when used in 4 c. c. doses, and in this test was apparently without value as an anthelmintic.

## OIL OF CHENOPODIUM

Oil of chenopodium in doses of 1 c. c. in 64 c. c. of castor oil failed to remove any thornheads present in 17 pigs of an average weight of 80.6 pounds. The average dose of oil of chenopodium recommended for a 100-pound pig for the removal of ascarids is from one-half to 1 fluid dram or from 2 to 4 c. c. The 1 c. c. dose, therefore, was well within the limits of safety and may have been too small. Larger doses should be tested, although the results in these experiments were not very promising.

## CONCLUSIONS

The following drugs were entirely ineffective in the removal of thorn-headed worms in the doses and manner used: Ethereal extract of male fern, kamala, a hyperactive solution of iodine, oil of chenopodium, and liquor cresolis compositus.

Kamala extract had too little efficacy to be of any promise and apparently does not warrant further test.

Tetrachlorethylene should be tested in larger doses.

Nicotine sulphate shows some promise for the removal of thornheads, especially when given with carbon tetrachloride, and this combination deserves further test. The doses of the nicotine sulphate and carbon-tetrachloride mixture used were injurious to the animals treated, but perhaps a satisfactory dosage and mode of treatment may be developed.

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May 14, 1936

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<i>Zoological Division</i> .....	MAURICE C. HALL, <i>Principal Zoologist, Chief.</i>



